The possible effects of extreme temperature on the eggs and nestlings of some woodland birds

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ABSTRACT

We document here the effects of an unusual temperature event related to a site in South East NSW that is the subject of a longitudinal study of the breeding biology of woodland birds. In the three breeding seasons before the 2009-10 season we recorded only one temperature above 40°C in November (40.9), and one in December (42.9). All other records above 40°C occurred in January when there were relatively few active nests. On November 20 2009 a temperature of 46.2°C was recorded, when there were 22 active nests. We are suggesting that at least six, and perhaps seven of these nests failed as a result of this event.

Key words: Temperature, nest failure, breeding, *Lichenostomus chrysops, Eopsaltria australis*

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Introduction

In the years 1975 to 1984 inclusive, Marchant (1992) studied the breeding biology of woodland birds on a 10 ha site at Maulbrooks Road, Moruya, NSW, Australia (35°52'S, 150°03'E). For about 50 species he collected data on numbers of breeding pairs, breeding period, territory size, numbers of nests found and nesting sites. His methods involved finding nests and monitoring these nests, in conjunction with observations of colour-banded birds.

The study site remained untouched after 1984 (essentially no human visitation) and therefore presented a unique opportunity to repeat Marchant's study 30 years later. The repeat study started at the beginning of the 2006/2007 breeding season (August-January inclusive).

Nest failures are common and can be attributed to a number of causes. Predation is by far the most common cause of failure, but extreme weather events can also cause failure. During the 2009/2010 breeding season we recorded the highest temperature of the four seasons since beginning the study. This extreme temperature appeared to be associated with a high number of nest failures on the study site that day. This paper reports a possible interpretation of the effect of an extreme temperature event, towards the middle of the 2009/2010 breeding season, on nest failure.

Methods

The backbone of the methods, as in the study by Marchant (1992), comprised finding and monitoring nests, and a banding program to maintain a high proportion of colour-banded birds. The study site was searched for an average of three hours on about 90% of the days in each breeding season. Locations of individuals and nests were mapped on each occasion. There was a major banding effort twice a year (in October and December), and individual birds were targeted in between these sessions. As a result, a significant proportion of colour-banded birds was maintained, with re-trap percentages during banding sessions (approximately 200 birds processed), as high as 58. Consequently, it was possible to recognize a high proportion of individual birds, pairs and sexes, we knew the breeding history of these birds, and were therefore in a good position to document the effects of any unusual occurrence on the nesting process.

Temperature was recorded in a Stevenson Screen on the SE corner of the site. The thermometer was a HOBO Temperature Data Logger with an accuracy of ± 0.47°C.

For statistical analysis, a generalized linear model was fitted to the number of nest failures as a function of the number of nests observed. The null model (a single overall mean failure rate fitted across the four breeding seasons, 06/07, 07/08, 08/09 and 09/10) was compared with a model fitted with a four level factor for the four seasons of data. To evaluate the likelihood of the number of nest failures observed in November 2009 we assumed that the number of nest failures per day was drawn from a Poisson distribution and evaluated the probability of observing five or more nest failures.

Results

Over the four years of the study we found between 84 and 108 nests (that progressed to having at least one egg) each season, representing about 30 species. The mean seasonal nest failure rate recorded was 59% with an observed range of 48% to 68%. There is no evidence that the seasonal nest failure rate for the fourth year is different from the earlier three years (Chi-square statistic 1.667 with 1 d.f., P = 0.64).

In the three seasons before the 2009/2010 season only one temperature above 40°C was recorded in November (2006; 40.9°C), and one in December (2006; 42.9°C). All other records above 40°C occurred in January when there were relatively few active nests (e.g. there were only 5 active nests on January 15, 2010). On November 20, 2009, a sudden increase in temperature, to 46.2°C was recorded (see Fig 1), when there were 22 active nests. Associated with this extreme event there were seven nest failures (Table 1). We suggest at least six of these may be attributed to this extreme temperature event based on the knowledge of the nest prior to the event and subsequent observations.

As a comparison, Group 2 comprised nests that survived the event, either as eggs or young, and is detailed in Table 2.

Five of the 22 active nests are not in either of the above lists. These are nests for which it was difficult to determine, in the short term, whether they were still active or not. Examples are very high nests (e.g. White-naped and Scarlet Honeyeater) or hole nests (e.g. Spotted Pardalote and White-throated Treecreeper).

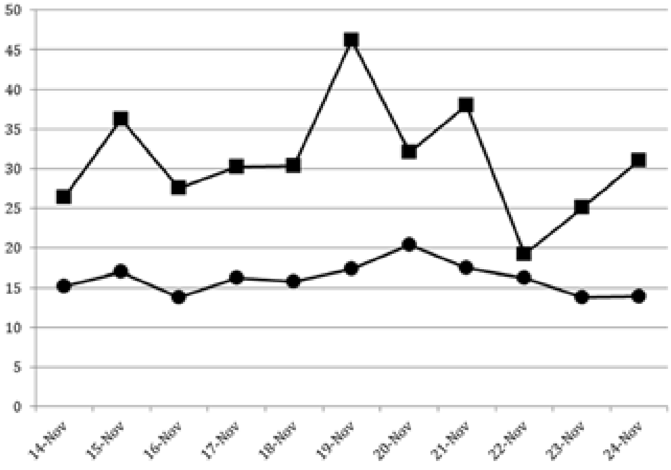

Figure 1. Maximum and minimum temperatures (°C) for the 10 days including November 20, 2009.

Discussion

There are two lines of analysis that suggest a link between the high temperature and the nest losses in Group 1. The first is a statistical one. The average number of nest failures per day across the four seasons was 0.31 (0.22 – 0.40). In the 2009/2010 season the average number of nest failures per day was 0.40, the highest recorded over the four-season period. Assuming a Poisson distribution to the observed number of nest failures per day and given a mean number per day of 0.40, the expected probabilities of getting zero, one, two through to six or more nest failures on a single day are; zero failures 0.76, one failure 0.26, two 0.054, three 0.007, four 0.0007, and five or more failures 0.00006. This analysis shows that it is unlikely that 7 nests would be lost on one day.

The second line of analysis is that of the circumstances of how the nests were lost. The two species that provide the most data in Group 1 in this regard are *Lichenostomus chrysops* and *Eopsaltria australis*. Group 1 contains two examples of Lichenostomus chrysops and one of *Eopsaltria australis* that abandoned eggs within days of the extreme temperature event. The number of dead young is one for both species. In comparison, over the previous three breeding seasons (not including 09/10), we found 68 nests of *Lichenostomus chrysops* and 62 nests of *Eopsaltria australis*, and only observed one instance of *Lichenostomus chrysops*, and three instances of *Eopsaltria australis* abandoning eggs. One of these cases (*Eopsaltria australis* abandoning eggs in December) can also be associated with a temperature over

Table 1. Details of the seven nests that failed (Group 1)

Common name	**Scientific name**	**Nest status at 20/11/2009**	**Outcome**
Yellow-faced Honeyeater	*Lichenostomus chrysops*	Eggs at least 7 days old.	Female sat on eggs for at least four days longer than the incubation period and finally abandoned them.
Yellow-faced Honeyeater	*Lichenostomus chrysops*	Eggs 12 days old.	Bird last seen on nest on 17.11.09. Eggs abandoned.
Yellow-faced Honeyeater	*Lichenostomus chrysops*	One dead young (about 8 days old).	One unhatched egg on 23.11.09
Eastern Yellow Robin	*Eopsaltria australis*	Female on eggs.	Female sat on eggs (including 20.11.09) for at least 5 days longer than the incubation period before abandoning them.
Eastern Yellow Robin	*Eopsaltria australis*	Two young in nest.	One dead young found out of nest on 21.11.09. The dead young had fledged at least 5 days early.
Golden Whistler	*Pachycephala pectoralis*	Two young hatched on 19 or 20.11.09.	Found dead in nest on 21.11.09.
Mistletoebird	*Dicaeum hirundinaceum*	On nest.	Nest abandoned at next observation on 25.11.09. It was impossible to inspect this nest so the nest could simply have been raided by a predator.

Table 2. Group 2: Details of the ten nests that survived the event, either as eggs or young.

Common name	Scientific name	Nest contents at 20 November 2009
Superb Fairy-wren	*Malurus cyaneus*	Eggs
Noisy Friarbird	*Philemon corniculatus*	Eggs or young
Noisy Friarbird	*Philemon corniculatus*	Eggs
Lewin's Honeyeater	*Meliphaga lewinii*	Young, or very late eggs
Yellow-faced Honeyeater	*Lichenostomus chrysops*	Eggs or newly hatched young
Eastern Spinebill	*Acanthorhynchus tenuirostris*	Young birds
Golden Whistler	*Pachycephala pectoralis*	Eggs
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	Eggs
Olive-backed Oriole	*Oriolus sagittatus*	Eggs
Satin Bowerbird	*Ptilonorhynchus violaceus*	Eggs

40°C. Similarly, over the same period, there are no instances of dead young in the nest for *Lichenostomus chrysops*, and only one instance for *Eopsaltria australis*. Although the data are limited, they suggest for the two species, that the scenarios associated with the loss (abandoned eggs or dead young in the nest) are not common, and appear temporally associated with extreme heat. These data are therefore consistent with the conclusion that the losses for these two species, immediately after November 20, 2009, are due to the extreme heat on that day. There are not enough data on the other two species in Group 1 to do a similar comparison.

The literature on this issue supports a view that the temperature we measured is at the top of the range tolerated by the eggs of a small passerine. The highest natural egg temperature we can find in the literature is that of an Eastern Song Sparrow *Melospiza melodia*, 45.8°C (Huggins 1941), but survival or otherwise of the egg was not noted. The thermal tolerance of the eggs of the House wren *Troglodytes aedon* is 10-47 °C (Baldwin and Kendeigh 1932).

Group 2 contains two species also found in Group 1: *Lichenostomus chrysops* and *Pachycephala pectoralis*. The reason for this may be microclimatic differences due to the location of the nests. It may also be that the eggs of *Pachycephala pectoralis* (Group 2) are more robust than the young (Group 1) in extreme heat. Location, microclimate and possibly behaviour, could also explain the survival of the nests of *Malurus cyaneus* and *Acanthorhynchus tenuirostris*, but there were no nests of these species in Group 1 for comparison. The rest of the species in Group 2 have relatively large eggs and may have survived due to a relatively small surface area to volume ratio and thus a larger thermal inertia.

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